Power Process Simulation

14th November 2006

Kolkata, India

Outline

- Power generation by boiler and gas turbine plants
- Simulation of modern combined cycle power plants
- Comparison of Greenhouse emissions and electricity costs with other common power systems

Power generation using UCG - Boiler plant

- **UCG has had a long history of use in providing supplementary fuel gas for use in coal-fired boilers in the Former Soviet Union**
- **The low radiant properties of the gas mean that usage is restricted to approximately 30% of the total fuel or a boiler designed for gas is required**
- **Only rudimentary cleaning of the gas is required to prevent fouling of pipework**

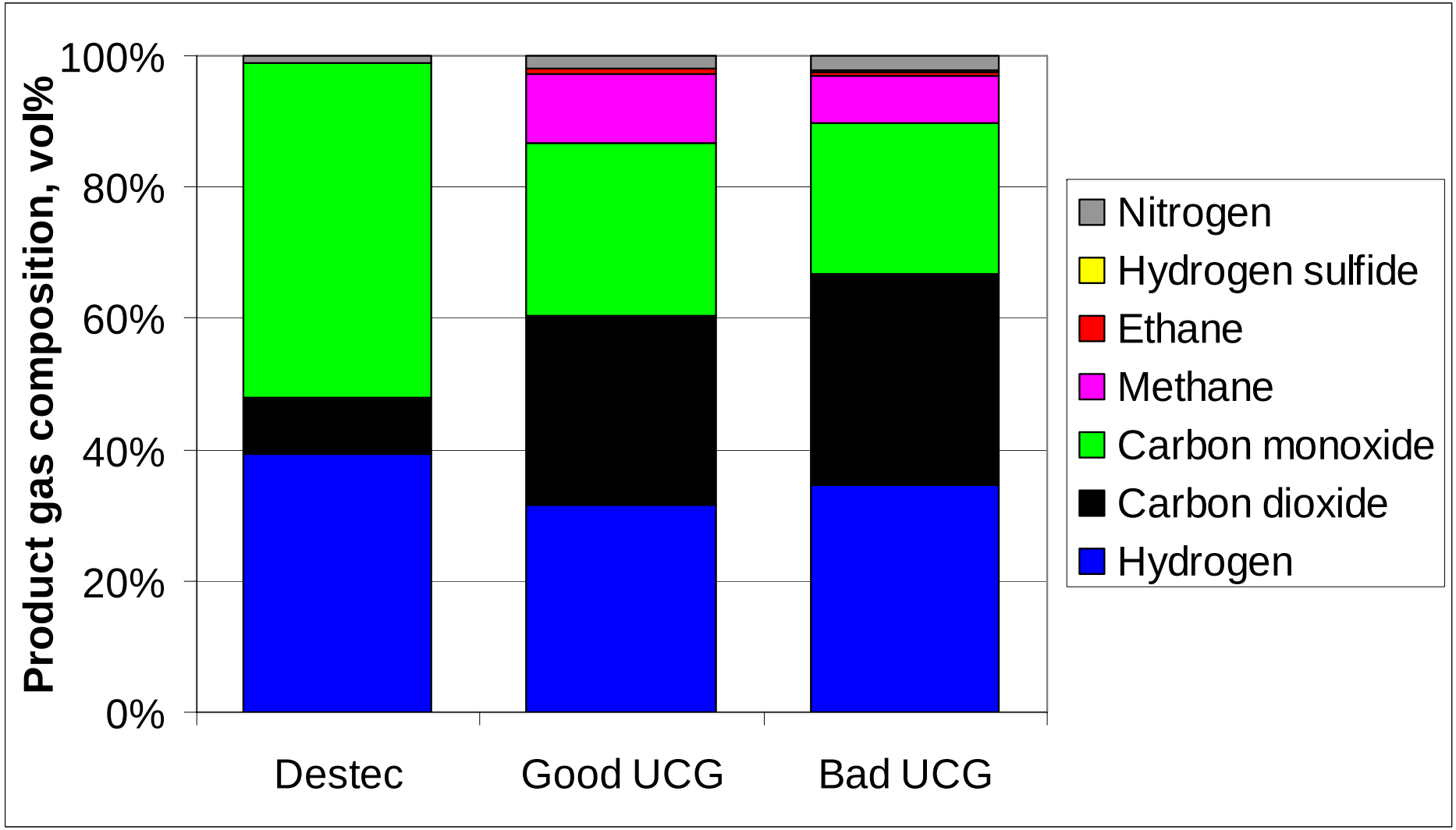
Power generation using UCG - Gas turbine plant

- **Advances in the design and construction of gas turbines means that there are now turbines available that can operate on gas from coal gasifiers, including UCG**
- **Combined cycle plants incorporating gas and steam turbines can provide high efficiency power generation from UCG**

UCG and gas turbines

- **UCG product gas has a different composition for every site and varies significantly from that of entrained flow gasifiers for IGCC systems**
- **This has an impact on the design of the turbine combustor and the turbine**
- **Turbines are typically specified on mass flow, so the different gas composition can impact on operation**

Example gas compositions



The ‘Good UCG’ case is the expected performance and the ‘Bad UCG’ case is an alternative prediction with some negative assumptions degrading performance.

Process options

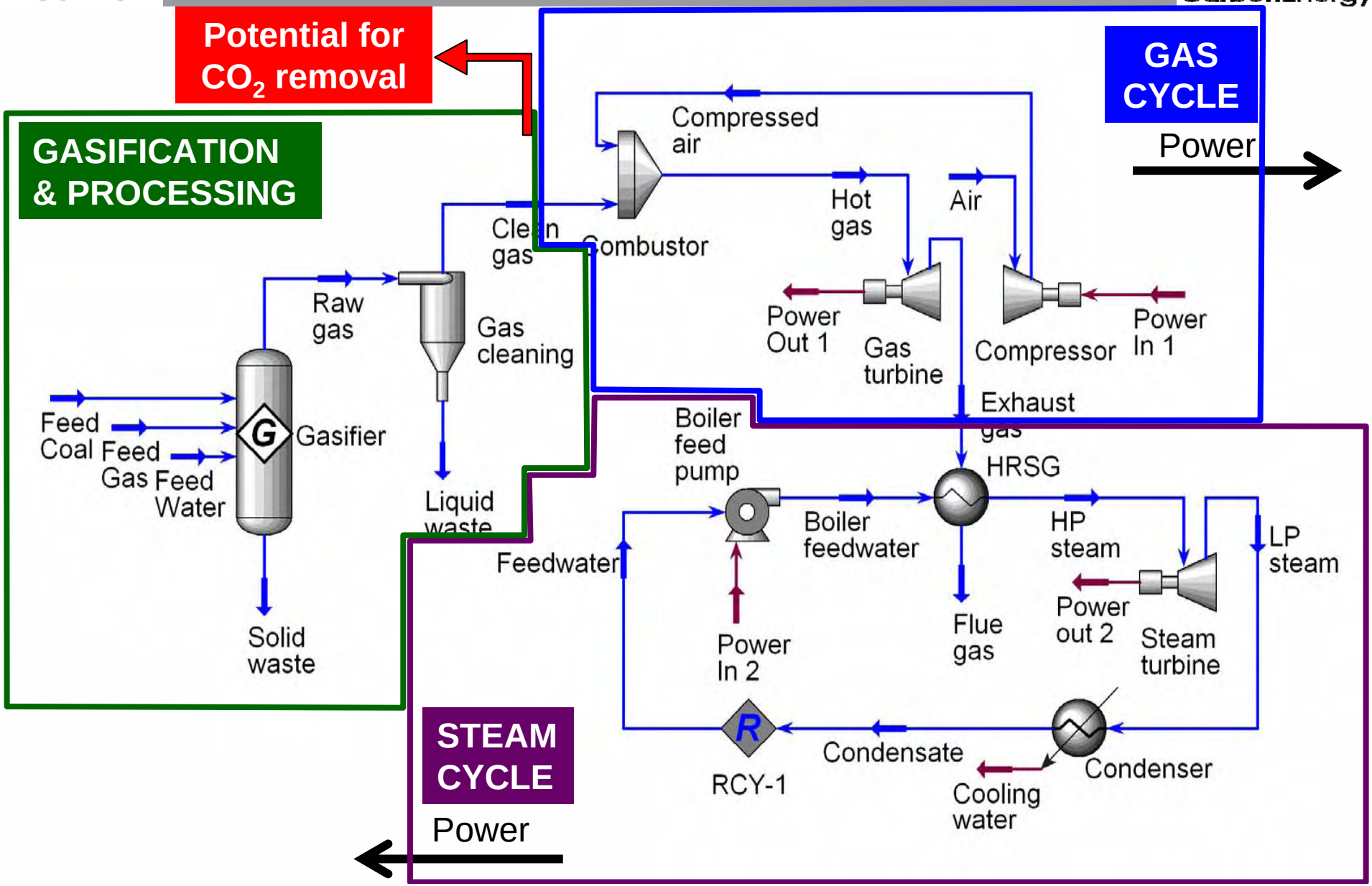
Process	Feed gas
Gas turbine combined cycle (IGCC)	**Surface coal gasifier (Destec)**
IGCC with CO_2 removal (IGCC-CO_2)	**UCG base case (Good UCG)**
IGCC with Shift and Removal (IGCC-Shift)	**UCG "worst" case estimate (Bad UCG)**

Note: All processes use commercially available technologies

Simulation method

- **HYSYS.Process, a commercial software package, is used for the basic power system modelling**
- **A specialised module was developed in HYSYS.Process to provide coal gasification performance input to the simulation**
- **Carbon dioxide removal and shift reactor performance were determined in a separate model**

Process simulation- Combined cycle electricity generation

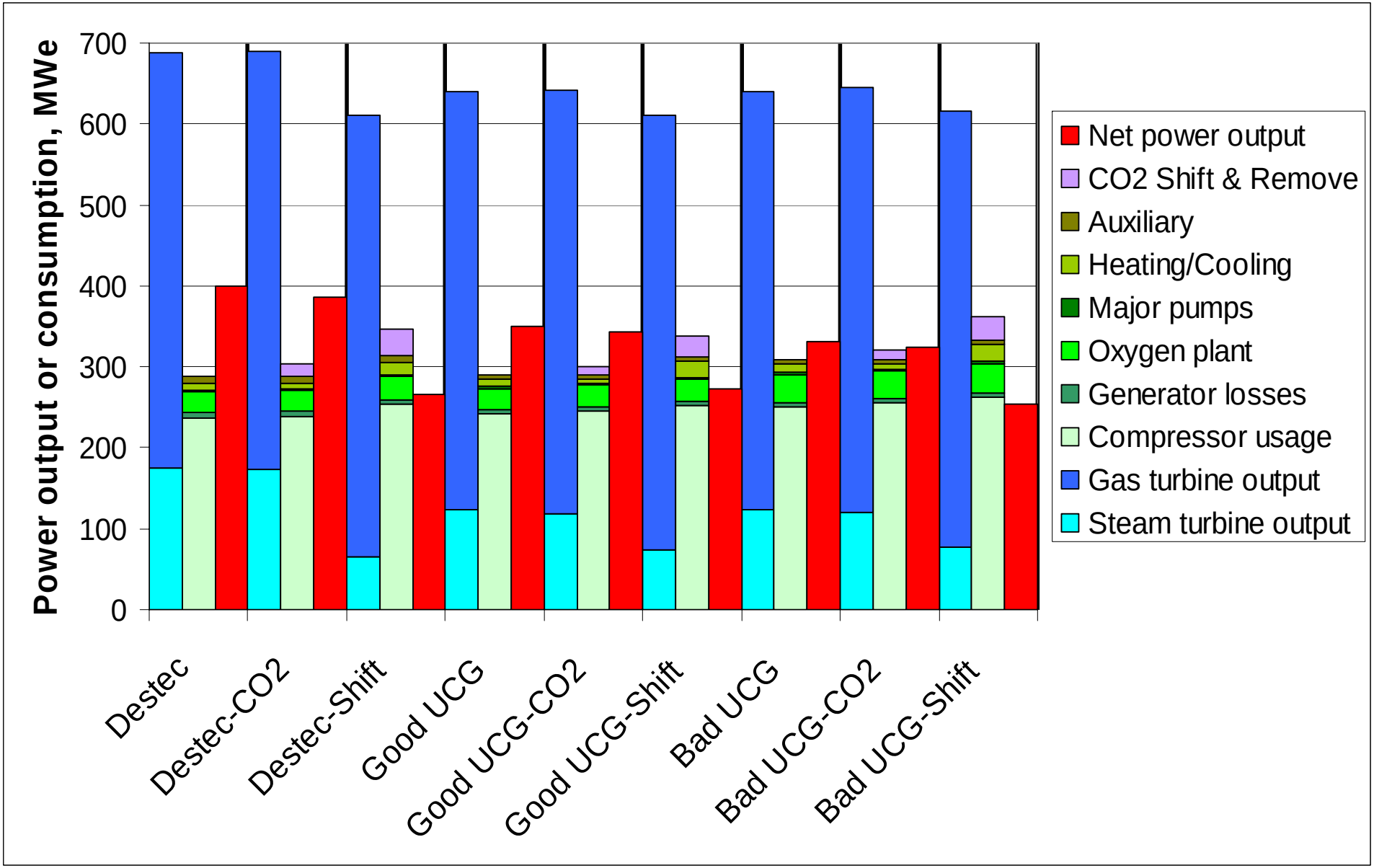


Variation in gas usage

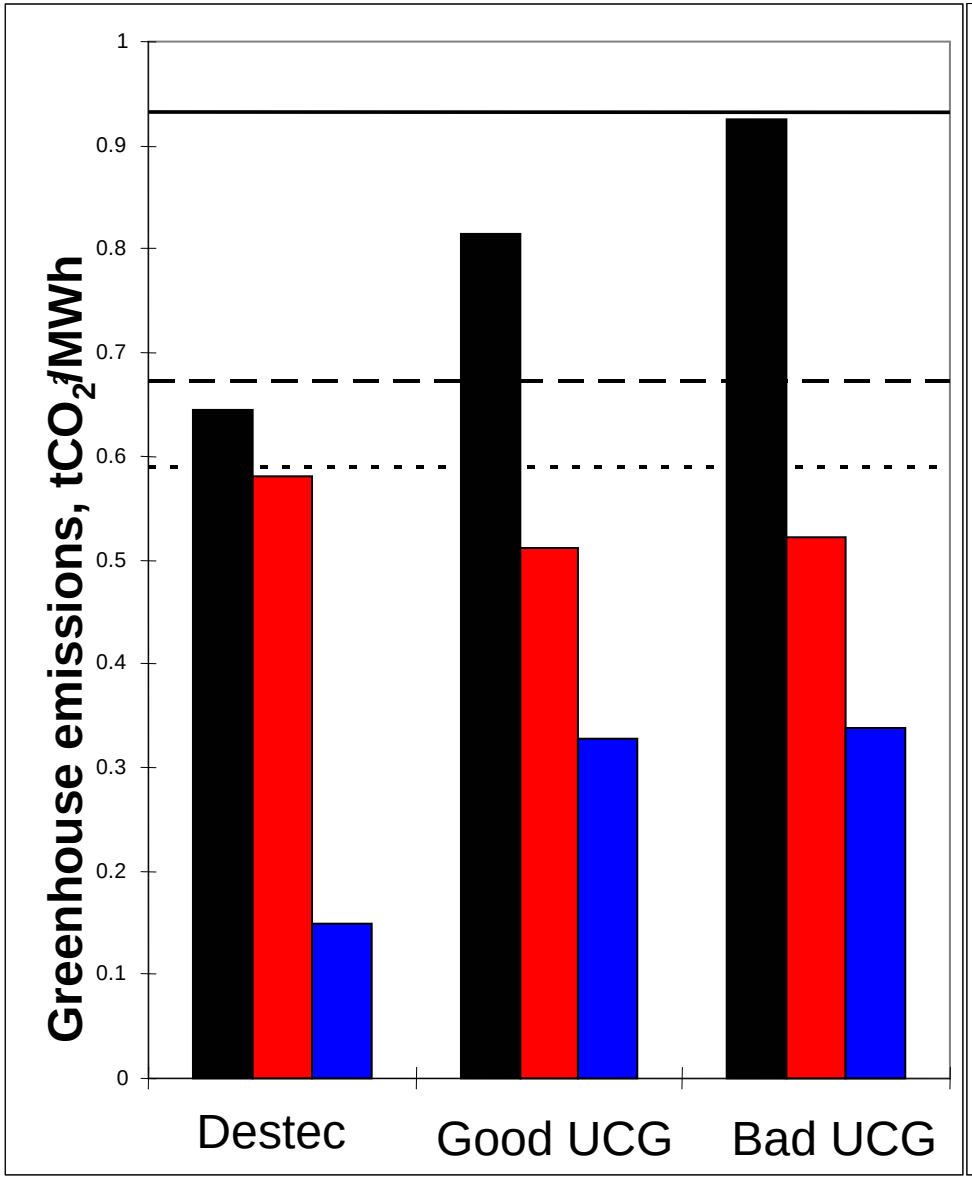
Mass flow to combustor	Destec kg/hr	Good UCG kg/hr	Bad UCG kg/hr
No CO2 removal	192705	220835	251500
90% of CO2 removed	192483	219270	249242
Shift then 90% of CO_2 removed	220636	234040	265760

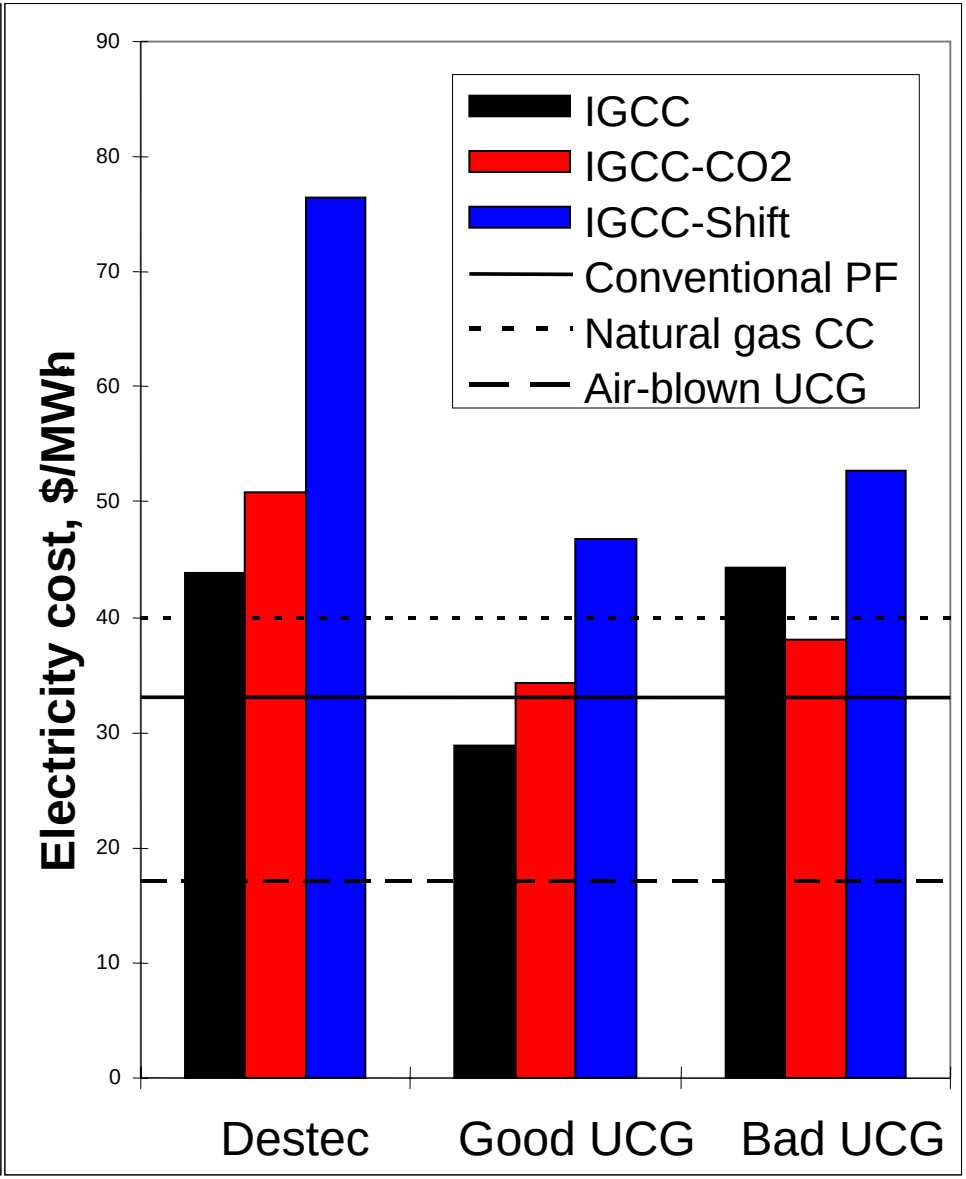
The different gas composition results in different requirements for the gas turbine to operate at maximum efficiency. In this case, the turbine design is not optimal for UCG and is more suitable for the Destec gas.

Power characteristics of the systems



Greenhouse emission and cost competitiveness for electricity





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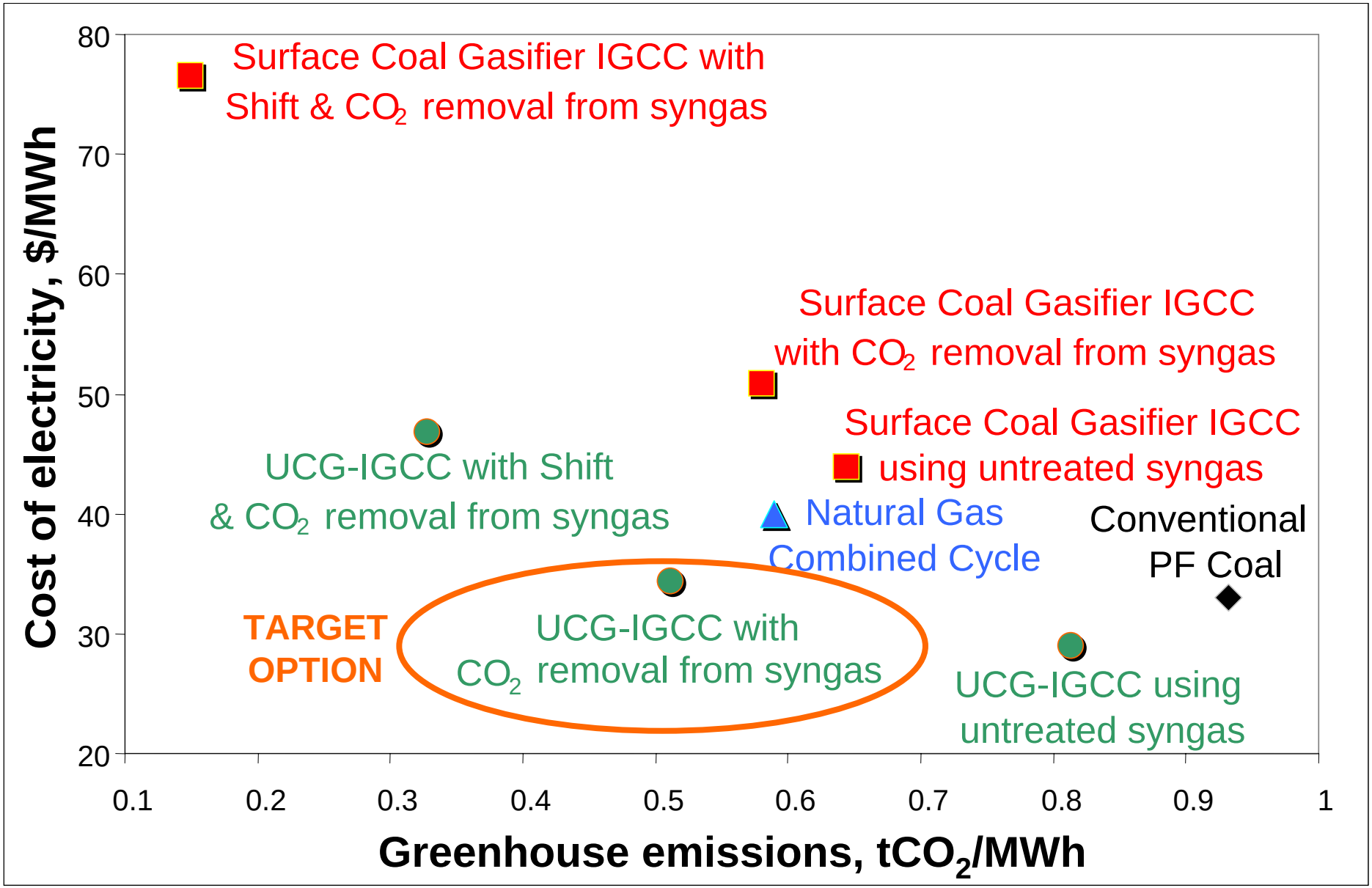

Approximate efficiencies for different generation processes

Process	Efficiency
Air-blown UCG	**45.4 %**
Oxygen-blown UCG	**46.5 %**
UCG with CO_2 separation	**39.8 %**
Conventional coal	**~37 %**
IGCC	**~45 %**

Conclusions

- **Underground coal gasification can provide an alternative source of fuel for power generation**
- **This fuel can be used efficiently in modern gas turbine plant, although some modifications must be made**
- **Carbon dioxide separation to reduce the Greenhouse emissions is feasible**
- **The cost of power can be competitive with conventional power generation**


Air compression
& separation
Liquid fuels
& Fertilisers
Electricity
Gasification

The End